Analysis and application of model predictive control in energy systems

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Background

Balancing the fluctuating renewable energy production to a fluctuating demand is becoming an increasing issue in modern energy systems. Apart from increasing renewable energy penetration, smarter and more efficient energy systems provide a feasible solution to achieve sustainable development and environment-friendly pathway. Advanced control strategies are strongly encouraged to be implemented in smart energy systems aiming to reduce energy consumption without sacrificing overall performance. The Model Predictive Control (MPC) approach has been gaining popularity among these control strategies due to its potentially superior performance. It optimally utilizes predictions of future disturbances and can deal with conflicting optimization goals. However, the configuration of MPC in specific energy systems remains challenging.

Problem statement

Previously, a large amount of research has been focused on MPC applications in different energy systems (e.g. solar tanks [1], HVAC [2], power plants [3] etc.). The implementation process of a typical MPC can be roughly divided into five steps:

- Selection and development of models
- Defining the cost or objective function
- Selection of the optimization technique
- Programming of control logic and strategies
- Testing and commissioning of the control

Model selection and the corresponding optimization techniques will significantly affect overall performance of MPC. Despite this, they are usually chosen based on researchers' experience and familiarity with given approaches. There is a lack of systematic studies comparing different modeling approaches and optimization techniques with respect to different applications. Such fact raises the question: is it possible to find best optimization scheme for a given type of energy system model?

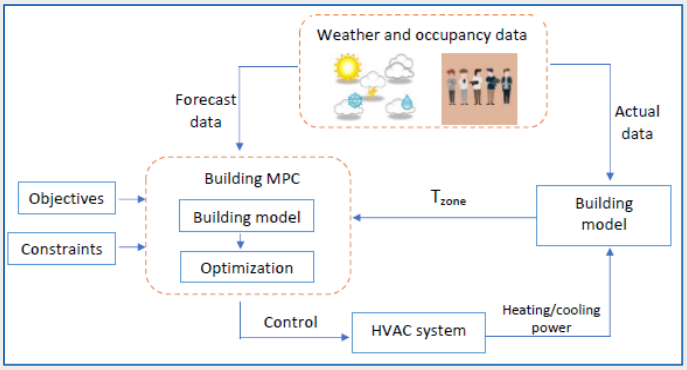

Fig. 1. Example of building MPC
(T_{zone} is temperature in specific building zone)

To answer the question a systematic evaluation is needed to assess the potential optimization schemes and their performance on models in different contexts.

Objective

The objective of this project is to find best combination of MPC models with optimization schemes within different energy systems.

Methodology

The methodology involves studying the effect of model types as well as optimization techniques on overall MPC performance. Building MPC (illustrated in Fig. 1.) will be appointed as typical energy system to be investigated followed by a district heating/cooling network and an industrial process.

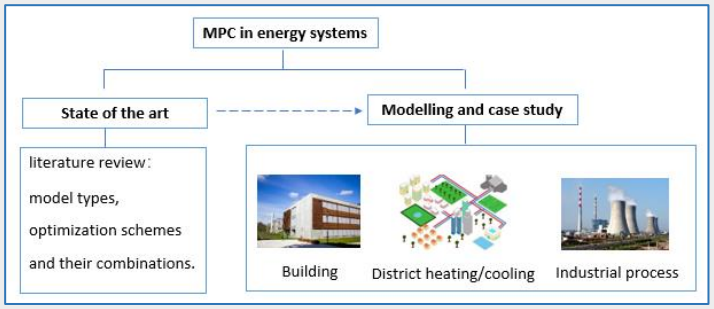

Fig. 2. Research workflow

Project period

01. October 2018 – 30. September 2021

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